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Monitoring a pilot CO_2 injection experiment in a shallow aquifer using 3D cross-well electrical resistance tomography

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Three dimensional electrical resistance tomography (ERT) was used to monitor a pilot CO_2 injection experiment at Vrøgum, Denmark. The purpose was to evaluate the effectiveness of the ERT method for monitoring the two opposing effects from gas-phase and dissolved CO_2 in a shallow unconfined siliciclastic aquifer. Dissolved CO_2 increases water electrical conductivity (EC) while gas phase CO_2 reduce EC. We injected 45kg of CO_2 into a shallow aquifer for 48 hours. ERT data were collected for 50 hours following CO_2 injection. Four ERT monitoring boreholes were installed on a 5m by 5m square grid and each borehole had 24 electrodes at 0.5 m electrode spacing at depths from 1.5 m to 13 m. ERT data were inverted using a difference inversion algorithm for bulk EC. 3D ERT successfully detected the CO_2 plume distribution and growth in the shallow aquifer. We found that the changes of bulk EC were dominantly positive following CO_2 injection, indicating that the effect of dissolved CO_2 overwhelmed that of gas phase CO_2. The pre-injection baseline resistivity model clearly showed a three-layer structure of the site. The electrically more conductive glacial sand layer in the northeast region are likely more permeable than the overburden and underburden and CO_2 plumes were actually confined in this layer. Temporal bulk EC increase from ERT agreed well with water EC and cross-borehole ground penetrating radar data. ERT monitoring offers a competitive advantage over water sampling and GPR methods because it provides 3D high-resolution temporal tomographic images of CO_2 distribution and it can also be automated for unattended operation. LLNL IM release#: LLNL-PROC-657944.

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